

## Unit 4 – Weather



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### A. Introduction

Weather - the day-to-day environmental conditions in a location.

Climate - the weather conditions of an area averaged over many years.

Weather Dynamic – the study of how the motion of water and air cause weather patterns

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### B. Earth's Energy Balance

Almost all of the energy used on earth to sustain life and cause our changing weather comes from the sun.

Energy can be transferred from one place to another by four methods:

1. Radiation is the transfer of energy through space by waves.

These waves are called the electromagnetic spectrum

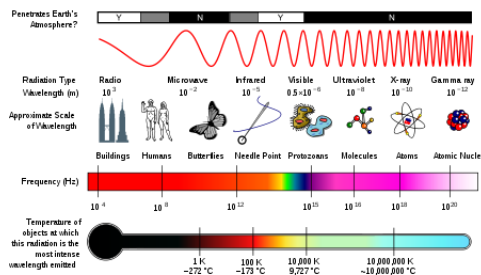
- Radio waves – used to send messages through radio, television, and radar
- Microwaves – used for communication, radar (speeding car), and power (cook food)
- Infrared (IR) – used for medicine (treat skin diseases and relieve the pain of sore muscles). Photographers use IR to take pictures with no light. Burglar alarms. Ovens.
- Visible – Red Orange Yellow Green Blue Violet
- Ultra Violet (UV) - light is found in sunlight
- X-rays are primarily used for diagnostic medicine
- Gamma rays can cause serious damage when absorbed by living tissue, and they are therefore a health hazard.

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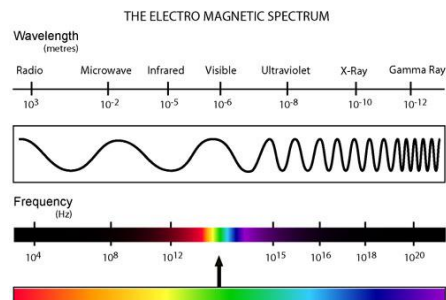
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2. Conduction is the transfer of energy through a substance by the collision of particles.
3. Convection is the vertical transfer of energy by the movement of particles in a fluid (liquid or gas).
4. Advection is the horizontal transfer of energy by the movement of particles in a fluid (liquid or gas).

Heat capacity is a measure of how much energy is required to raise the temperature of a substance.

Heat Sink – any object or material that absorbs energy and becomes warmer.

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### C. The Atmosphere

The atmosphere is the gaseous envelope that surrounds the Earth.

Contains:

- O<sub>2</sub> N<sub>2</sub> and CO<sub>2</sub> responsible for supporting life
- Ozone (O<sub>3</sub>) used to block UV rays
- Water vapor needed for the water cycle

Needed for:

- Protection against comets and meteors (burn up by friction)
- Maintaining an average temperature by trapping heat reflected by the ground

Altitude – the height above sea level measured in meters or kilometers.

The lithosphere is the solid, inorganic outer shell of the Earth.

The hydrosphere is the waters of the Earth.

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The atmosphere consists of multiple layers: troposphere, tropopause, stratosphere, mesosphere, thermosphere, and exosphere.

Troposphere – the atmospheric layer closest to the earth's surface. Responsible for most of the weather temperature decreases with increased altitude

Tropopause – a thin layer that absorbs more heat than the troposphere and separates it from the higher levels

Stratosphere – contains most of the ozone which protects the earth from harmful radiation

Mesosphere – temperature and gas concentration are very low

Thermosphere – absorbs most of the high energy waves from the sun which increases the temperature

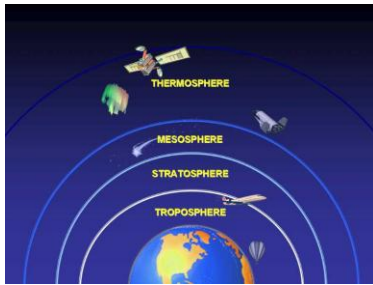
Exosphere – essentially space

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Atmospheric pressure – force the air exerts as gravity pulls it toward the center of the earth.

Temperature Gradient – the change in temperature over a distance

- Ex. In the troposphere the temperature gradient is  $-6^{\circ}\text{C}$  per 1000m

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## D. Prevailing Wind Patterns

Prevailing winds – winds that effect large areas

Jet Streams – high-speed winds in the upper regions of the troposphere

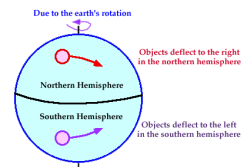
- A jet stream develops where air masses of differing temperatures meet.

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Coriolis Effect – the apparent change of direction of a moving object in a rotating system

- Once air has been set in motion by the pressure gradient force, it undergoes an apparent deflection from its path, as seen by an observer on the earth. This apparent deflection is called the "Coriolis force" and is a result of the earth's rotation.



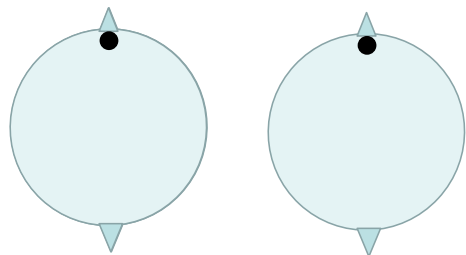
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- As air moves from high to low pressure in the northern hemisphere, it is deflected to the right by the Coriolis force. In the southern hemisphere, air moving from high to low pressure is deflected to the left by the Coriolis force.

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In a rotating system, when the puck is sent across a frictionless surface, when you look from above, you can see the puck travel straight and the circle rotate.

<http://www.youtube.com/watch?v=Wda7azMvabE>

## Air Movement

- **Wind** is the movement of air caused by differences in air pressure
- The **greater** the difference, the **faster** the wind moves

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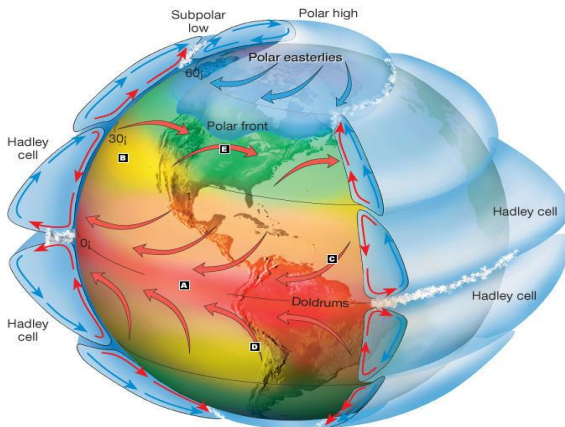
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## Air Pressure

- Differences in air pressure are caused by the **uneven heating** of Earth
- Uneven heating produces **pressure belts** which occur every 30° latitude

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## Pressure Belts

- As **warm air** rises at the equator and moves toward the poles, it cools
- As it cools, some of the air sinks around **30° north and south** of the equator

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## Pressure Belts

- At the poles, **cold air sinks** and moves towards the equator
- Around **60° north and south**, the air begins to heat up and rise

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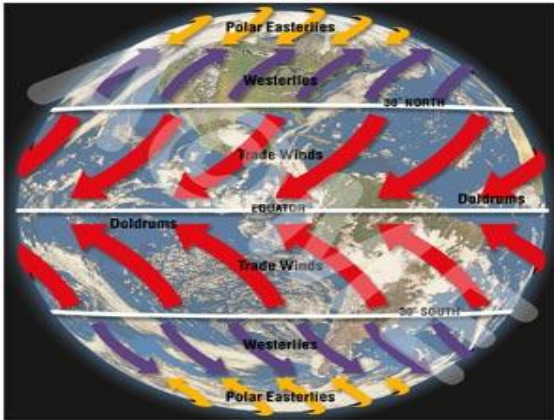
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## Global Winds

- The combination of pressure belts and the Coriolis Effect cause **global winds**
- These are **polar easterlies, westerlies, and trade winds**

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## Polar Easterlies

- Wind belts that extend from the **poles to 60° latitude**
- Formed from cold sinking air moving from the poles creating **cold temperatures**

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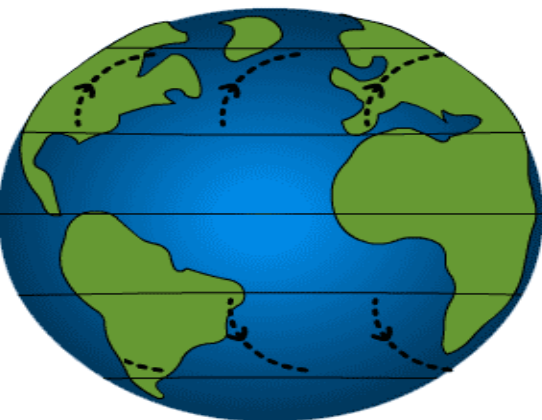


## Westerlies

- Wind belts found **between 30° and 60° latitude**
- Flow towards the poles from west to east carrying **moist air** over the United States

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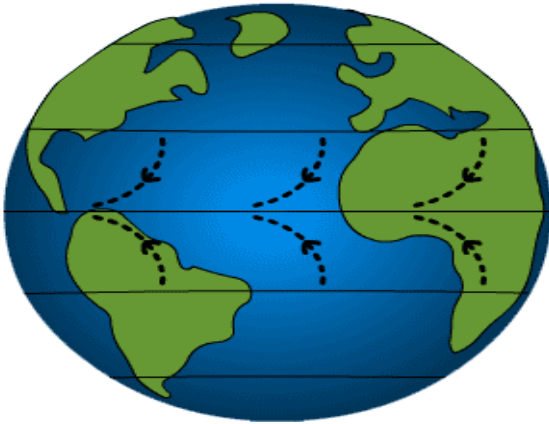


## Trade Winds

- Winds that blow from **30° almost to the equator**
- Called the trade winds because of their use by **early sailors**

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## Doldrums

- Located along the equator where **no winds blow** because the warm rising air creates an area of low pressure

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## Horse Latitudes

- Occur at about 30° north and south of the equator where the winds are **very weak**
- Most deserts on the Earth are located here because of the **dry air**

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## Jet Stream

- The jet streams are narrow belts of **high speed winds** that blow in the upper troposphere and lower stratosphere
- **Separates** warm air from cold air

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## Local Winds

- Generally move **short distances** and can blow in any direction
- Caused by **geographic features** that produce temperature differences

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## E. Hydrosphere

Causes of prevailing winds:

- convection currents (warm air rises)
- earth's eastward rotation

Effects of prevailing winds:

- distribute solar energy from the equator to cooler regions
- carry moisture

Hydrosphere – All of earth's water (solid, liquid and vapor/gas) both fresh and salt

The Water Cycle – SEE BIOLOGY NOTES

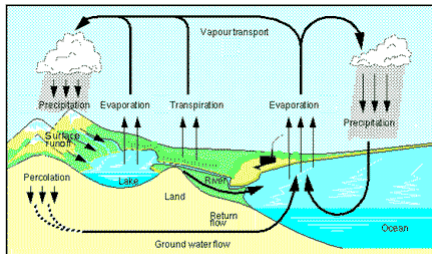
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Courtesy Erich Roeckner, Max Planck Institute for Meteorology

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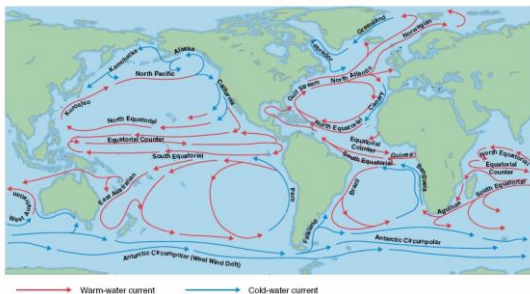
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## F. Major Ocean Currents

Ocean currents distribute warm water and energy from the equator around the world.

Causes of Ocean currents:

- Convection currents
- Wind across the ocean
- Earth's rotation
- Shapes of the continents
- Heat capacity of water
- Salinity of the water (salt content)



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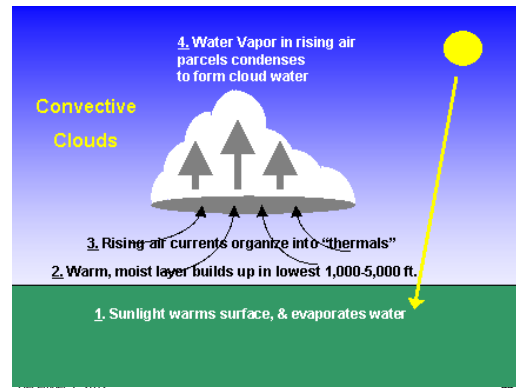
Warm water makes warm air that holds more moisture, cold water creates cold air that does not hold much moisture.

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## G. Clouds and Fog

### a. Formation of Clouds

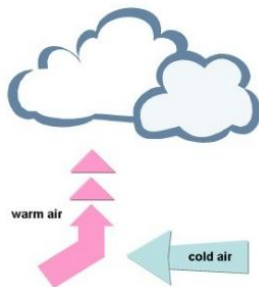
Convective Clouds – air near the grounds get warm rises until it expands and cools the water vapor condenses



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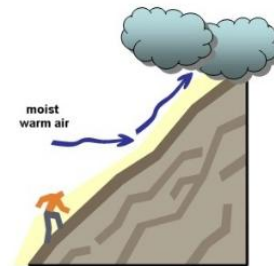
Frontal Clouds – one air mass meets another at different temperatures forcing the colder one down cooling the more hydrated warmer one



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Orographic Clouds – air moves up a mountain expands and cools condensing the water vapor

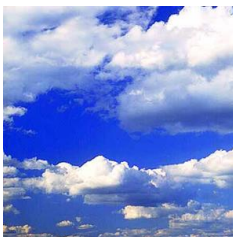


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### b. Classification of Clouds

Cumulus Clouds – have a billowing round shape and indicate unstable weather



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Stratus Clouds – have a flattened layered shape and indicate stable conditions



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## H. A Global Weather Model

Solar Energy – amount of sunlight

Cloud Cover – clouds help to maintain the energy balance on earth

Earth's Rotation – causes winds to twist to the right in the northern hemisphere

Jet Stream – high speed winds in the upper atmosphere

Prevailing Winds – large scale winds that move warm air from the equator to the poles

Ocean Currents – distribute energy from the equator to the poles and move cold water from the poles to the equatorial regions

Land Masses – heats up and cools down much faster than water and effects cloud formation

Hydrosphere – all of earth's water fresh and salt liquid and ice

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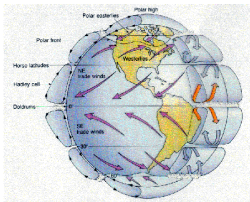
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## I. Weather Systems

Weather system – a set of temperature, wind, pressure, and moisture conditions that move as a unit

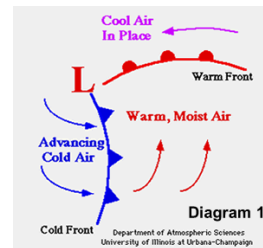


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Air Mass – a large body of air in which temperature and moisture are uniform

Low-Pressure System – tend to bring cloudy skies and stormy weather



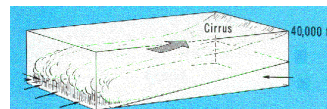
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- Low pressure systems are generally formed by air becoming less dense as a result of heating..
- If a *low pressure system* is coming, then look for warmer weather, storms and rain.

A front is the leading edge of an air mass.

A warm front is the leading edge of a warm air mass.



- Moves slower
- The rain falls in front of the front
- Gentle rain for a long period of time.

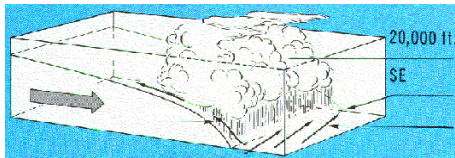
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A cold front is the leading edge of a cold air mass.



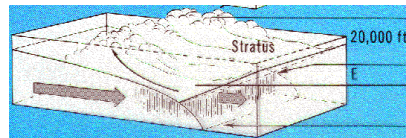
- Moves faster than the warm.
- Rain falls on top of the front.
- Short period of heavy rain & maybe thunder

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A stationary front forms when a cold and warm air mass meet, but neither moves.

An occluded front forms when a cold front overtakes a slower-moving warm front.



- Combination of warm front and then cold front
- A long period of gentle rain followed by heavy rain & possibly a t-storm

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### High-Pressure System

High pressure systems occur often, but not always, when there is an uneven heating of the ground, causing the hot air to rise and spread out. This rising air creates an air "void", or a low-pressure system in the area above the ground. However, when the air cools and sinks back down to the ground, a high-pressure system is created. High pressure systems are associated with clear, cool weather. Around high-pressure systems, winds flow clockwise in the northern hemisphere, counterclockwise in the southern hemisphere.

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### Weather Systems

#### Temperature

#### Wind

#### Radar and Satellite

**Read Pages 683 - 685**

**Case Study 14.3 Pg 550 - 552 a – l**

**Understanding Concepts # 1 – 5**

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### **J. Regional Weather**

Weather patterns are influenced on a global scale by prevailing winds and ocean currents.

Regional weather is the influence in much smaller regions.

Thermal – A local convection current

Sea Breeze – thermals that form near a body of water in the morning allows air flow from the water to the land (cool to warm) (land is warmer than water due to heat capacities)

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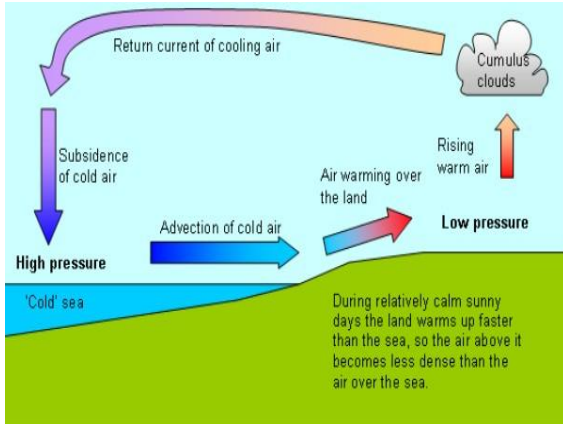
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### Sea Breezes

- High pressure is created over the ocean during the day and low pressure over land due to **uneven heating**
- Air moves from the ocean to the land creating a **sea breeze**

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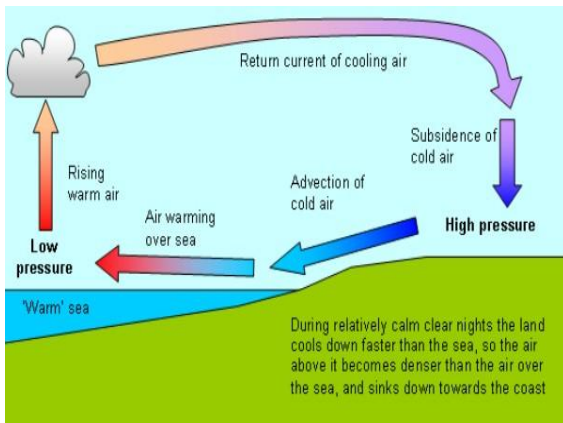


## Land Breezes

- Low pressure occurs over the ocean **during the night** and high pressure over land due to the uneven heating of earth
- This causes wind to move from the land to the ocean creating a **land breeze**

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Land Breeze – as the day ends the air flows from the land to the water (cool to warm)

Lake-Effect Snow – As air masses pass over bodies of water they pick up moisture

Chinook Winds – a warm eastward wind from the Rocky Mountains

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## K. Precipitation

Precipitation is water that falls to the ground in liquid or solid form.

Drizzle is falling water droplets that have a diameter between 40 µm and 0.5 mm.

Rain is falling water droplets that have a diameter between 0.5 mm and 5 mm.

Sleet is ice pellets (frozen raindrops) that bounce upon impact with the ground.

Snow is frozen water crystals that form below 0°C.

Fog is water droplets, ice crystals, or smoke particles that collect near the Earth's surface and that reduce visibility to less than 1 km.

Hail is frozen water droplets that are created by cycling through highly active thunderclouds many times.

Dew is water vapour that condenses on cool surfaces near the Earth's surface, typically in the morning.

A cloud is a collection of small water or ice particles occurring above the Earth's surface.

Clouds are classified according to their height of occurrence and shape.

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The water cycle or hydrologic cycle is a model that describes the storage and movement of water between the atmosphere, hydrosphere, and lithosphere

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*Hurricane Ivan—the ninth-named tropical storm of the 2004 hurricane season—spawned a brief resurgence of interest in global warming.*

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Global Warming is the increase in the average Earth's temperature due to an increased concentration of greenhouse gases in the atmosphere that amplifies the Greenhouse Effect.

Ozone,  $O_3$ , is a gas that consists of three oxygen atoms.

Smog is a generic term used to describe mixtures of pollutants in the atmosphere.

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## L. Global Climate Change

Climate change is a change in the “average weather” that a given region experiences. Average weather includes all the features we associate with the weather such as temperature, wind patterns, and precipitation.

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## M. The Greenhouse Effect and Ozone Depletion

The Greenhouse Effect is a natural process by which a planet's atmosphere traps thermal energy from the Sun, causing the temperature of the atmosphere to increase.

Greenhouse Gases such as water vapour, carbon dioxide, methane, ozone, nitrous oxides, and chlorofluorocarbons absorb and re-emit infrared radiation in the atmosphere.

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